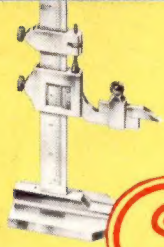
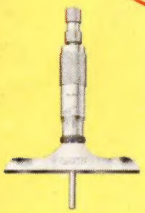
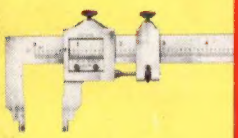


Starrett®



how to READ USE CARE FOR micrometers and vernier gages



English and Metric Graduations

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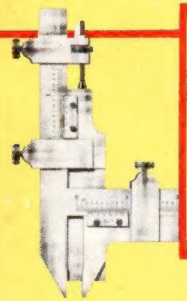

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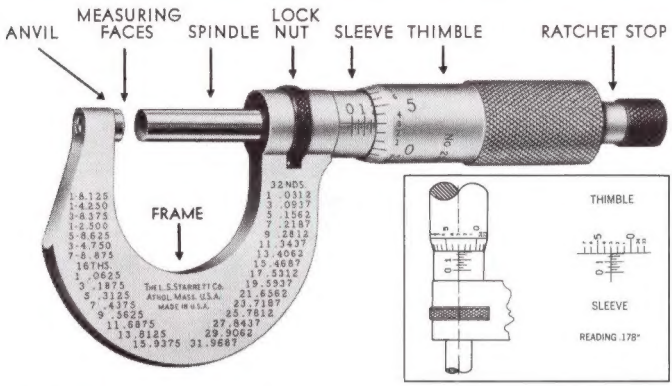
Rochester, N. Y. 14603

Micrometer Construction and Operating Principle

The micrometer caliper consists of a highly accurate ground screw or spindle which is rotated in a fixed nut, thus opening or closing the distance between two measuring faces on the ends of anvil and spindle. A piece of work is measured by placing it between the anvil and spindle faces and rotating the spindle by means of the thimble until anvil and spindle both contact the work. The desired work dimension is then found from the micrometer reading indicated by the graduations on the sleeve and thimble as described on the following pages.

How to Read a Starrett Micrometer Caliper Graduated in Thousandths of an Inch



Since the pitch of the screw thread on the spindle is 1/40" or 40 threads per inch in micrometers graduated to measure in inches, one complete revolution of the thimble advances the spindle face toward or away from the anvil face precisely 1/40 or .025 inches.

The reading line on the sleeve is divided into 40 equal parts by vertical lines that correspond to the number of threads on the spindle. Therefore, each vertical line designates 1/40 or .025 inches and every fourth line which is longer than the others designates hundreds of thousandths. For example: the line marked "1" represents .100", line marked "2" represents .200", and line marked "3" represents .300", etc.

The beveled edge of the thimble is divided into 25 equal parts with each line representing .001" and every line numbered consecutively. Rotating the thimble from one of these lines to the next moves the spindle longitudinally 1/25 of .025" or .001 inches; rotating two divisions represents .002", etc. Twenty-five divisions indicate a complete revolution, .025 or 1/40 of an inch.

To read the micrometer in thousandths, multiply the number of vertical divisions visible on the sleeve by .025", and to this add the number of thousandths indicated by the line on the thimble which coincides with the reading line on the sleeve.

Example: Refer to the illustration above:

The "1" line on sleeve is visible, representing ..... .100"

There are 3 additional lines visible, each representing .025"

3 x .025" = .075"

Line "3" on the thimble coincides with the reading line on the sleeve, each line representing .001"

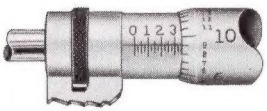
3 x .001" = .003"

The micrometer reading is ..... .178"

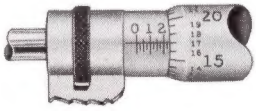
An easy way to remember, is to think of the various units as if you were making change from a ten dollar bill. Count the figures on the sleeve as dollars, the vertical lines on the sleeve as quarters, and the divisions on the thimble as cents. Add up your change and put a decimal point instead of a dollar sign in front of the figures.

Test Readings

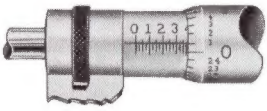
Write answers to test readings on dotted lines below.



Reading A.....



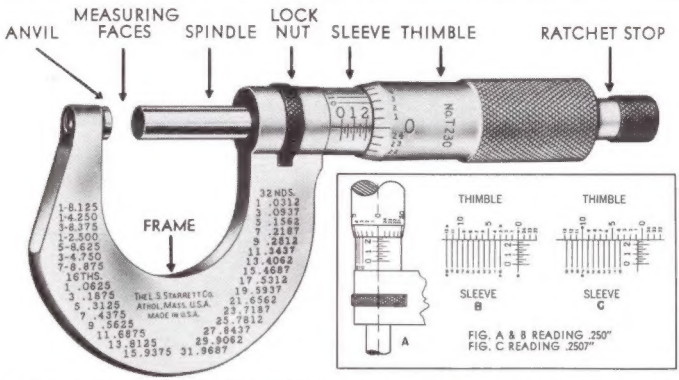
Reading B.....



Reading C.....

Answers: A .369 B .242 C .376

How to Read a Starrett Micrometer Caliper Graduated in Ten-Thousandths of an Inch



Starrett Micrometers graduated in ten-thousandths of an inch are used like micrometers graduated in thousandths as described on the preceding page, except that an additional reading in ten-thousandths which is obtained from a vernier is added to the thousandths reading.

The vernier consists of ten divisions on the sleeve, shown in figure B, which occupy the same space as nine divisions on the thimble. Therefore, the difference between the width of one of the ten spaces on the vernier and one of the nine spaces on the thimble is one-tenth of a division on the thimble, or one-tenth of one-thousandth, which is one ten-thousandth. To read a ten-thousandths micrometer, first obtain the thousandths reading, then see which of the lines on the vernier coincides with a line on the thimble. If it is line marked "1" add one ten-thousandths, if it is line marked "2" add two ten-thousandths, if it is line marked "3" add three ten-thousandths, etc.

Example: Refer to figures A and B above.

The "2" line on sleeve is visible, representing ..... .200"

There are two additional lines visible, each representing .025"
2 x .025" = .050"

Line "0" on the thimble coincides with the reading line on the sleeve, representing ..... .000"

The "0" lines on the vernier coincide with lines on the thimble, representing ..... .0000"

The micrometer reading is ..... .2500"

Example: Refer to figure C above.

The "2" line on sleeve is visible, representing ..... .200"

There are two additional lines visible, each representing .025"
2 x .025" = .050"

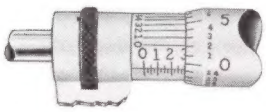
The reading line on the sleeve lies between the "0" and "1" on the thimble indicating ten-thousandths of an inch are also to be added as read from the vernier .....

The "7" line on the vernier coincides with a line on the thimble, representing ..... 7 x .0001" = .0007"

The micrometer reading is ..... .2507"

Test Readings

Write answers to test readings on dotted lines below.

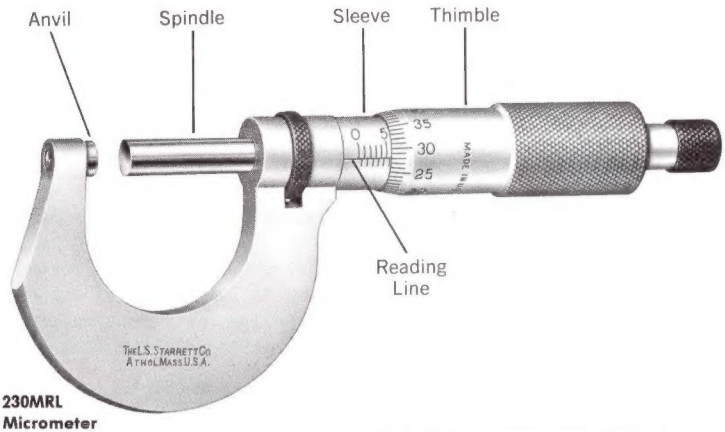


Reading A .....

Reading B .....

Answers: A .2992 B .3008

How to Read a Micrometer Graduated in Hundredths of a Millimeter (0.01 mm)



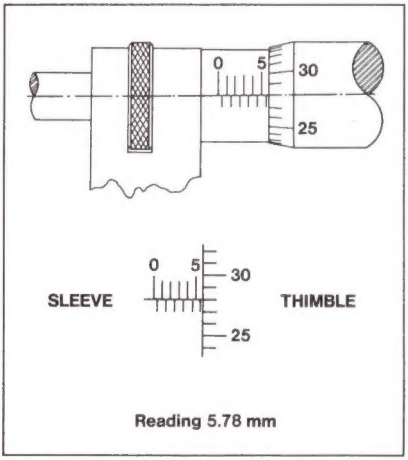
No. 230MRL
Outside Micrometer

Since the pitch of the spindle screw is one-half millimeter (0.5 mm), one revolution of the thimble advances the spindle toward or away from the anvil the same 0.5 mm distance.

The reading line on the sleeve is graduated in millimeters (1.0 mm) with every fifth millimeter being numbered from 0 to 25. Each millimeter is also divided in half (0.5 mm), and it requires two revolutions of the thimble to advance the spindle 1.0 mm.

The beveled edge of the thimble is graduated in 50 divisions, every fifth line being numbered from 0 to 50. Since one revolution of the thimble advances or withdraws the spindle 0.5 mm, each thimble graduation equals 1/50 of 0.5 mm or 0.01 mm. Thus two thimble graduations equal 0.02 mm; three graduations 0.03 mm, etc.

To read the micrometer, add the number of millimeters and half-millimeters visible on the sleeve to the number of hundredths of a millimeter indicated by the thimble graduation which coincides with the reading line on the sleeve.

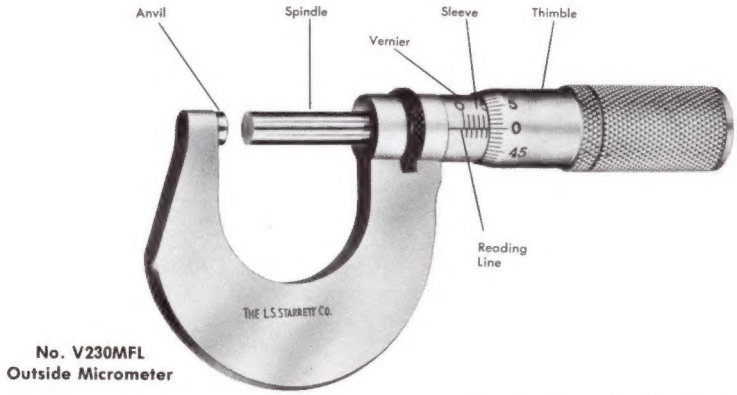


EXAMPLE

Referring to the picture and drawing:

The 5 mm sleeve graduation is visible	5.00 mm
One additional 0.5 mm line is visible on the sleeve	0.50 mm
Line 28 on the thimble coincides with the reading line on the sleeve, so 28 x 0.01 mm =	0.28 mm
The micrometer reading is	5.78 mm

How to Read a Vernier Micrometer Graduated in Two-Thousandths of a Millimeter (0.002 mm)



No. V230MFL
Outside Micrometer

Metric vernier micrometers are used like those graduated in hundredths of a millimeter (0.01 mm), except that an additional reading in two-thousandths of a millimeter (0.002 mm) is obtained from a vernier scale on the sleeve.

The vernier consists of five divisions each of which equals one-fifth of a thimble division—1/5 of 0.01 mm or 0.002 mm.

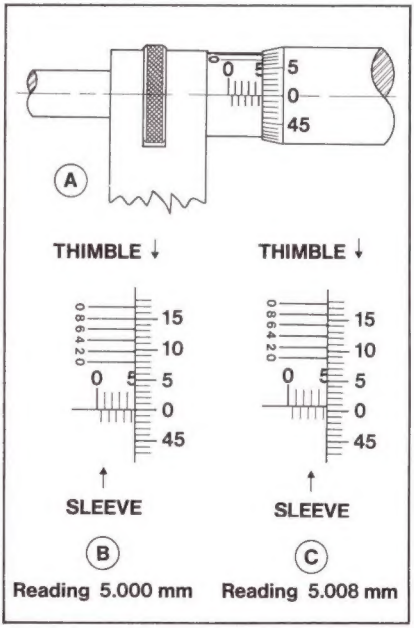
To read the micrometer, obtain a reading to 0.01 mm in the same way shown on the opposite page. Then see which line on the vernier coincides with a line on the thimble. If it is the line marked 2, add 0.002 mm; if it is the line marked 4, add 0.004 mm, etc.

EXAMPLE—Referring to drawings A and B:

The 5 mm sleeve graduation is visible	5.000 mm
No additional lines on the sleeve are visible	0.000 mm
Line 0 on the thimble coincides with the reading line on the sleeve	0.000 mm
The 0 lines on the vernier coincide with lines on the thimble	0.000 mm
The micrometer reading is	5.000 mm

EXAMPLE—Referring to drawing C:

The 5 mm sleeve graduation is visible	5.000 mm
No additional lines on the sleeve are visible	0.000 mm
Line 0 on the thimble lies below the reading line on the sleeve, indicating that a vernier reading must be added.	
Line 8 on the vernier coincides with a line on the thimble	0.008 mm
The micrometer reading is	5.008 mm



How to Read and Use a Micrometer Depth Gage

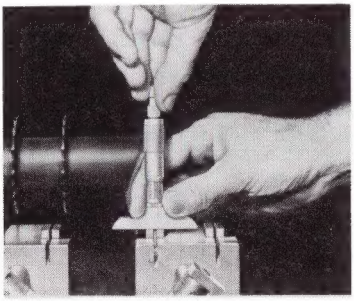
A micrometer depth gage, as the name implies, was designed to measure the depth of holes, slots, recesses, keyways, etc.

The tool consists of a hardened, ground and lapped base combined with a micrometer head. Measuring rods with individual length adjustment are inserted through a hole in the micrometer screw and brought to a positive seat by a knurled nut. The screw is precision ground and has a one-inch movement. The rods are furnished to measure in increments of one inch. Each rod protrudes through the base and moves as the thimble is rotated.

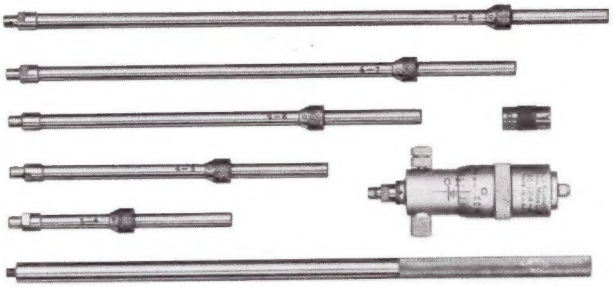
The reading is taken exactly the same as with an outside micrometer except that sleeve graduations run in the opposite direction. In obtaining a reading using a rod other than the 0-1", it is necessary to consider the additional rod length. For example, if the 1-2" rod is being used, one inch must be added to the reading on the sleeve and thimble. When using the 2-3" rod, two inches must be added to the reading, and so on.

Before using the micrometer depth gage, be sure that base, end of rod, and work are wiped clean, and that rod is properly seated in micrometer head. Hold base firmly against work as shown below, and turn thimble until rod contacts bottom of slot or recess. Tighten lock nut and remove tool from work to read measurement.

Adjustment to compensate for wear is provided by an adjusting nut at the end of each rod. Should it become necessary to make an adjustment of a rod, back off the adjusting nut one-half turn before turning to new position.



How to Read and Use an Inside Micrometer



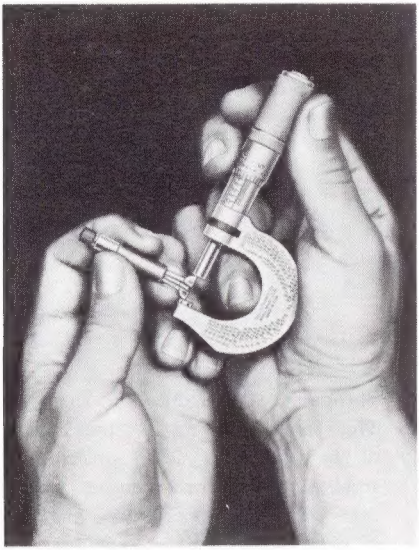
An inside micrometer is used for measuring inside diameters of cylinders, rings, for setting calipers, comparing gages and measuring between parallel surfaces. The measurement is taken over the ends or contacts and read off the micrometer head in thousandths of an inch. Greater distances are measured by using extension rods and gages (or collars) provided with each tool.

Assemble selected measuring rod to micrometer head, making sure to wipe dirt from both rod shoulder and head and align zero lines on rod and head. Hold assembled tool across diameter of work as shown below with one end contacting work. Screw micrometer head thimble until other end lightly contacts work. Be sure to rock gage slightly in different directions to "feel" true diameter of work. Set tool to this true diameter, then take reading exactly as with an outside micrometer (page 3). Add micrometer reading to rod length to obtain total measurement.

In addition to measuring rods, Starrett No. 124 Inside Micrometers (as shown above) are furnished with one or more gages or spacing collars. These are assembled between the measuring rod shoulder and micrometer head to extend range of tool by ½ or 1 inch depending on length of gage used.

Measuring rods can be individually adjusted to take up wear, and micrometer head is also adjustable for wear on its screw. A knurled extension handle is available for obtaining inside measurements in hard-to-reach locations.

How to Use, Adjust and Care for Micrometers

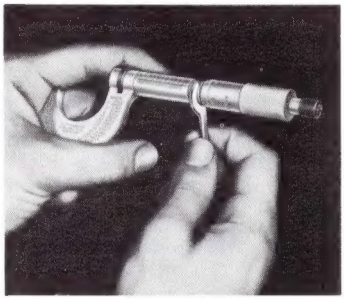


Starrett Friction Thimble Micrometers give uniform contact pressure for correct readings every time independent of "feel".

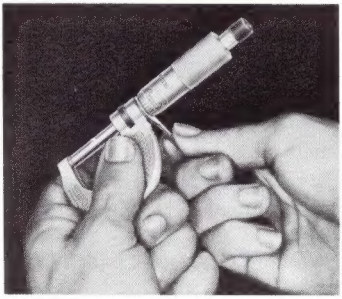
For most measurements the micrometer is held as shown. The work is placed against the anvil with the left hand while the spindle is turned down on work with thumb and index finger of right hand. Caution: Do not force measurement—light contact pressure assures correct reading. After some practice, you will develop a measuring "feel" that will give your readings automatic accuracy.

Do not remove work from micrometer before taking reading. If reading cannot be seen without removing micrometer, lock the spindle at the final setting with the lock nut and slide micrometer off work by the frame.

Adjusting a Starrett Micrometer can be done in two easy steps. To eliminate play in spindle, back off the thimble, insert spanner wrench (furnished with micrometer) and tighten just enough to eliminate play. See top illustration at right. To adjust zero reading, clean all dirt or grit from measuring faces, bring them together, and insert spanner wrench in the small slot of the sleeve as shown lower right. Then turn sleeve until its zero line coincides with zero line on thimble.



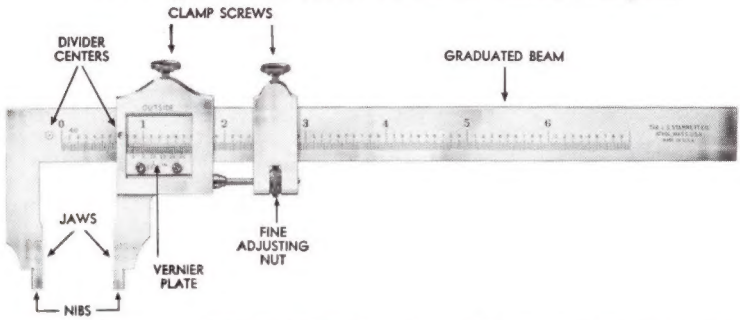
Caring for your micrometer requires little effort, pays off in long, accurate life. Be sure to check your micromter periodically for accuracy, making adjustments shown above as required. An occasional drop of Starrett Precision Instrument Oil on spindle and spindle threads also assures free running performance.



Always **wipe** off your micrometer before putting away—never use air hose as this is apt to force dirt and grit into spindle threads. For convenient storage, Starrett offers a variety of cases for pocket and tool chest use.

Vernier Caliper Construction and Operating Principle

See Pages 12, 13 for 50-Division Vernier Calipers



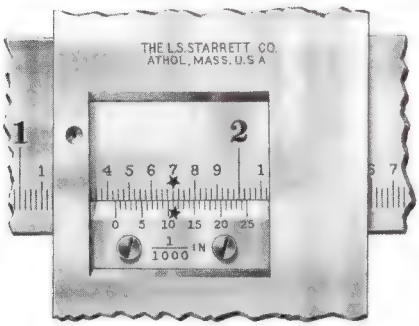
A vernier caliper consists basically of a stationary part and a movable part. The stationary part is the hardened graduated bar with fixed measuring jaw, hardened ground and lapped in one piece from finest tool steel. The movable part is the vernier slide assembly combining the movable jaw and vernier plate along with clamp screws and adjusting nut. The vernier slide moves as a unit along the graduated beam to bring both jaws in contact with work, and readings are taken in thousandths of an inch by the position of the vernier plate zero line in relation to the bar graduations.

Unlike vernier height and depth gages shown on pages 14-16, the vernier caliper beam is graduated both sides to provide both outside and inside measurements. Outside readings are taken from left to right, inside readings from right to left. When jaws are brought together, the zero line on the "outside" vernier plate coincides with the zero line on the beam. Turn the caliper over and you will see that the zero line on the "inside" vernier plate falls a number of graduations beyond the zero line on the beam. This inside reading is the thickness of the nibs when closed, which is the smallest inside measurement you can take with the caliper. Since the width of both nibs must be included in all inside measurements, you can see that all Starrett Vernier Calipers automatically compensate for this on the "inside" vernier plate, making all inside measurements direct.

Like any precision measuring tool, a vernier caliper must not be forced. Move vernier slide by hand until jaws contact work. Tighten clamp screw located over fine adjusting nut and turn fine adjusting nut until jaws engage work firmly but **not too tightly**. Then tighten clamp screw over vernier plate and carefully remove caliper to get reading.

An extra feature of Starrett Vernier Calipers is the divider centers on beam and vernier slide—these centers permit extremely accurate setting of divider and trammel points for precise layout work.

How to Read a 25-Division Vernier Graduated in English and Metric (Direct Reading)



Reading 1.436 in.

English Reading

Inches are numbered in sequence over the full range of the bar. Every fourth graduation between the inch lines is numbered and equals one-tenth of an inch or .100". Each bar graduation is one twenty-fifth of an inch or .025".

The vernier plate is graduated in 25 parts, each representing .001". Every fifth line is numbered—5, 10, 15, 20, 25—for easy counting.

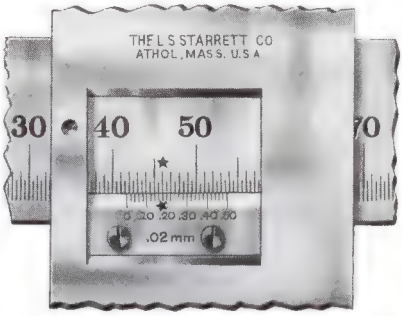
To read the gage, first count how many inches, tenths (.100") and twenty-fifths (.025") lie between the zero line on the bar and the zero line on the vernier plate and add them.

Then count the number of graduations on the vernier plate from its zero line to the line that coincides with a line on the bar.

Multiply the number of vernier plate graduations you counted times .001" and add this figure to the number of inches, tenths and twenty-fifths you counted on the bar. This is your total reading.

EXAMPLE

In the picture, the vernier plate zero line is one inch (1.000") plus four tenths (.400") plus one twenty-fifth (.025") beyond the zero line on the bar, or 1.425". The 11th graduation on the vernier plate coincides with a line on the bar (as indicated by stars). 11 x .001" (.011") is therefore added to the 1.425 bar reading, and the total reading is 1.426".



Reading 41.68 mm

Metric Reading

Each bar graduation is 0.5 mm. Every twentieth graduation is numbered in sequence—10 mm, 20 mm, 30 mm, 40 mm, etc.—over the full range of the bar. This provides for direct reading in millimeters.

The vernier plate is graduated in 25 parts, each representing 0.02 mm. Every fifth line is numbered in sequence—0.10 mm, 0.20 mm, 0.30 mm, 0.40 mm, 0.50 mm—providing for direct reading in hundredths of a millimeter.

To read the gage, first count how many mm lie between the zero line on the bar and the zero line on the vernier plate.

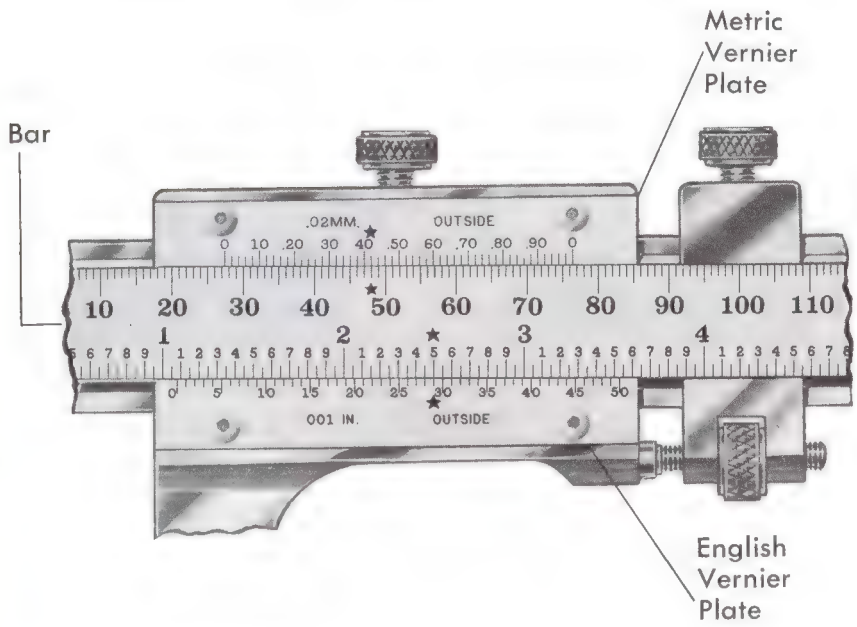
Then find the graduation on the vernier plate that coincides with a line on the bar and note its value in hundredths of a mm.

Add the vernier plate reading in hundredths of a mm to the number of mm you counted on the bar. This is your total reading.

EXAMPLE

In the picture, the vernier plate zero line is 41.5 mm beyond the zero line on the bar, and the 0.18 mm graduation on the vernier plate coincides with a line on the bar (as indicated by stars.) 0.18 mm is therefore added to the 41.5 mm bar reading, and the total reading is 41.68 mm.

How to Read a 50-Division Vernier Gage Graduated in English and Metric (Direct Reading)



English Reading

Refer to the lower bar graduations and the English Vernier plate. Inches are numbered in sequence over the full range of the bar. Every second graduation between the inch lines is numbered and equals one-tenth of an inch or .100". Each bar graduation is one-twentieth of an inch or .050".

The vernier plate is graduated in 50 parts, each representing .001". Every fifth line is numbered—5, 10, 15, 20 . . . 45, 50—for easy counting.

To read the gage, first count how many inches, tenths (.100") and twentieths (.050") lie between the zero line on the bar and the zero line on the vernier plate and add them.

Then count the number of graduations on the vernier plate from its zero line to the line that coincides with a line on the bar. Multiply the number of vernier plate graduations you counted times .001" and add this figure to the number of inches, tenths and twentieths you counted on the bar. This is your total reading.

EXAMPLE

In the picture, the vernier plate zero line is one inch (1.000") plus one twentieth (.050") beyond the zero line on the bar, or 1.050". The 29th graduation on the vernier plate coincides with a line on the bar (as indicated by stars). 29 x .001 (.029") is therefore added to the 1.050" bar reading, and the total reding is 1.079".

Metric Reading

Refer to the upper bar graduations and metric vernier plate. Each bar graduation is 1.00 mm. Every tenth graduation is numbered in sequence—10 mm, 20 mm, 30 mm, 40 mm, etc.—over the full range of the bar. This provides for direct reading in millimeters.

How to Read a 50-Division Vernier Gage Graduated in English and Metric (Direct Reading) continued

The vernier plate is graduated in 50 parts, each representing 0.02 mm. Every fifth line is numbered in sequence—0.10 mm, 0.20 mm, 0.30 mm . . . 0.80 mm, 0.90 mm—providing for direct reading in hundredths of a millimeter.

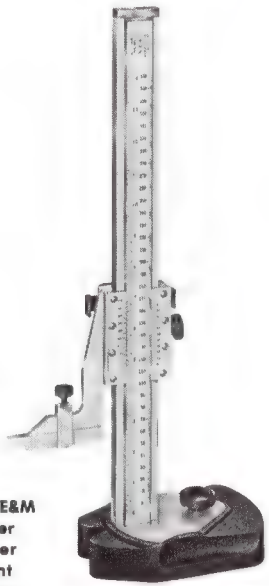
To read the gage, first count how many mm lie between the zero line on the bar and the zero line on the vernier plate.

Then find the graduation on the vernier plate that coincides with a line on the bar and note its value in hundredths of a mm.

Add the vernier plate reading in hundredths of a mm to the number of mm you counted on the bar. This is your total reading.

EXAMPLE

In the picture, the vernier plate zero line is 27 mm beyond the zero line on the bar, and the 0.42 mm graduation on th vernier plate coincides with a line on the bar (as indicated by stars). 0.42 mm is therefore added to the 27 mm bar reading, and the total reading is 27.42 mm.



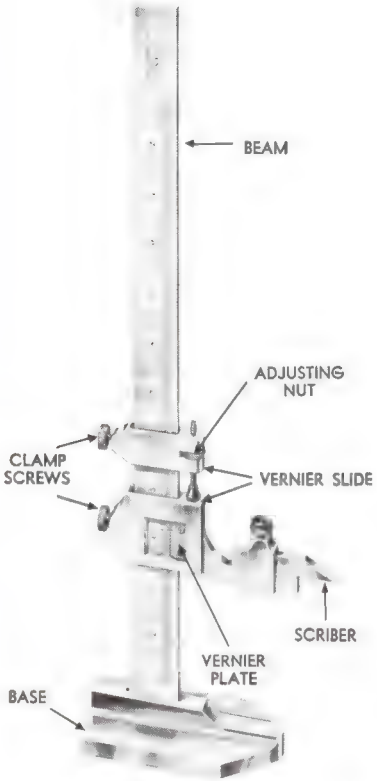
No. 254E&M Master Vernier Height Gage

Graduated .001" and .02 mm; fine adjusting knob in base; quick release for fast vertical adjustment; rounded scriber point; long, open face, flush fitting vernier slide; hardened bar; glare-free satin chrome finish.

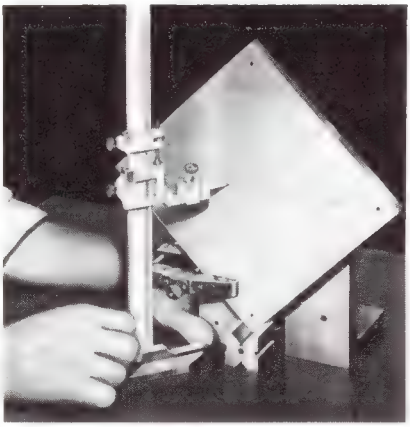
No. 123E&M Satin Chrome Master Vernier Caliper

Graduated .001" and .02 mm (add .250" or 6.35 mm nib thickness for inside readings); center points for setting dividers; long, open face, flush fitting vernier slide; hardened bar; glare-free satin chrome finish.

Vernier Height Gage Construction and Operating Principle



No. 454 VERNIER HEIGHT GAGE



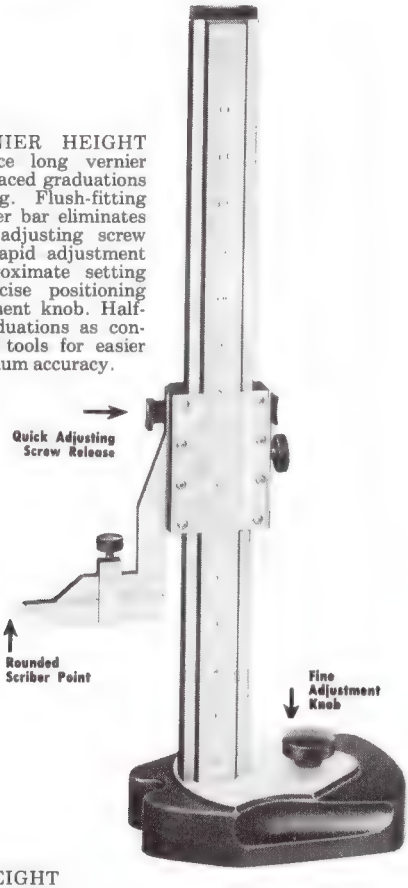
Like the vernier caliper described on pages 10 and 11, the vernier height gage consists of a stationary part and a movable part. The stationary part combines a graduated, hardened and ground beam with a hardened, ground and lapped base. The movable part is the vernier slide assembly which can be raised or lowered to any position along the bar and adjusted in thousandths of an inch by means of the vernier plate fine adjusting nut.

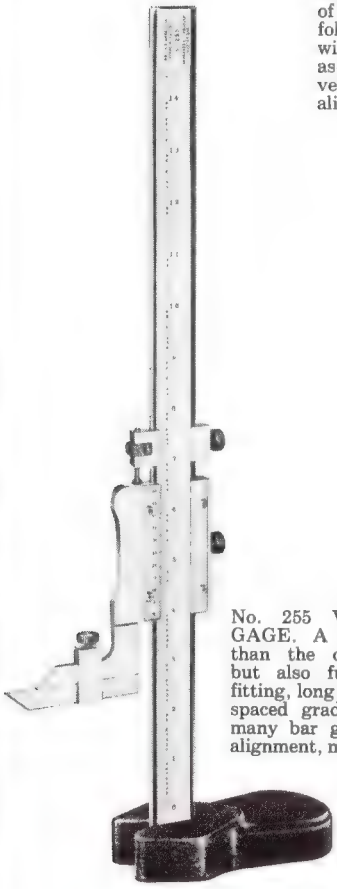
Set up as shown left with hardened steel scriber clamped to the vernier slide, the vernier height gage is used on a surface plate or machine table to mark off vertical distances and locate center distances. Replacing scribers with a Starrett "Last Word" Indicator changes over vernier height gage for use as a precision inspection gage for comparing heights from a plane surface. Other accessories extending vernier height gage uses include depth attachment, tungsten carbide scribers, offset scribers and toolmakers' buttons for accurate hole location.

Beam and vernier plate graduations are identical with the outside scale of the vernier caliper and readings are taken exactly as described on pages 11 and 12.

Vernier Height Gages with 50-Division Verniers

No. 254 VERNIER HEIGHT GAGE. Open-face long vernier with 50 widely spaced graduations for easy reading. Flush-fitting vernier and master bar eliminates parallax. Quick adjusting screw release permits rapid adjustment of slide to approximate setting followed by precise positioning with fine adjustment knob. Half-as-many bar graduations as conventional vernier tools for easier alignment, maximum accuracy.





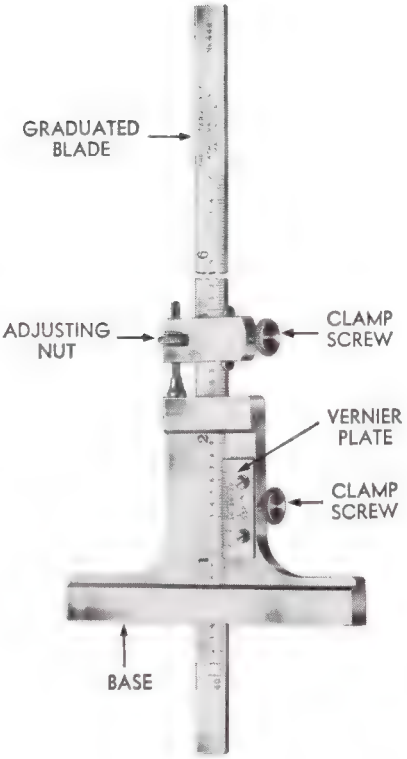
No. 255 VERNIER HEIGHT GAGE. A lighter weight gage than the one shown at right but also furnished with flush-fitting, long vernier with 50 widely spaced graduations and half as many bar graduations for easier alignment, maximum accuracy.

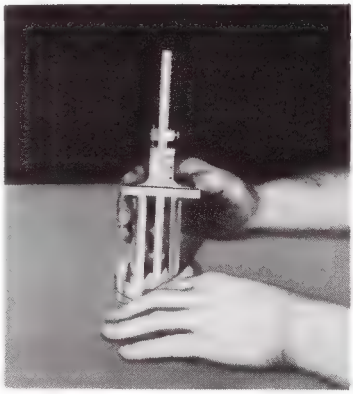
Vernier Depth Gage Construction and Operating Principle

The vernier depth gage differs slightly from the vernier caliper and vernier height gage in that the vernier slide remains fixed while the graduated blade is moved to obtain desired measurement in thousandths of an inch. The vernier slide also forms the base which is held on work by one hand while the blade is operated with the other.

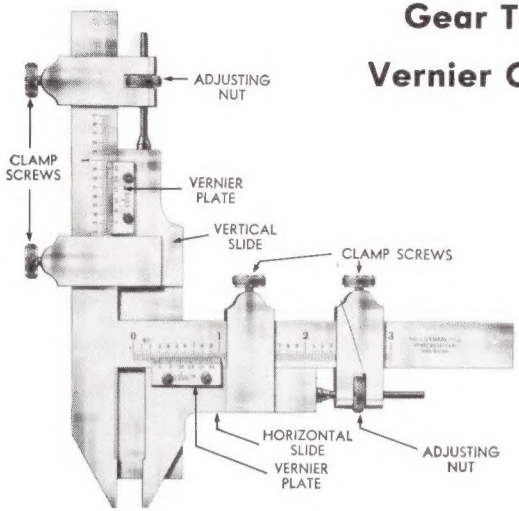
Obtaining a measurement is accomplished same as with a vernier caliper or height gage. After blade is brought into contact with bottom of slot or recess (see application below), clamp screw adjacent to fine adjusting nut is locked. Then fine adjusting nut is turned to obtain exact measurement, which is then locked in position by clamp screw beside vernier plate.

The blade is graduated in fortieths of an inch (.025")—just like the vernier caliper—with vernier plate graduations also the same. The gage is read exactly as shown on page 11.





Gear Tooth Vernier Caliper



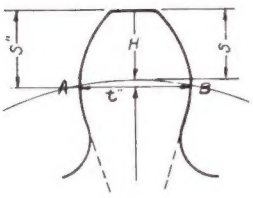
- **Construction**
- **Measuring Principle**
- **How to Read**

The gear tooth vernier caliper measures chordal thickness, or thickness at the pitch line of a gear tooth to one thousandth of an inch. Its construction combines in one tool the functions of both vernier depth gage and vernier caliper.

The vertical slide is set to depth by means of its vernier plate fine adjusting nut so that when it rests on top of the gear tooth, the caliper jaws will be correctly positioned to measure across the pitch line of the gear tooth. The horizontal slide is then used to obtain the chordal thickness of the gear tooth by means of its vernier plate fine adjusting nut.

Starrett No. 456 Gear Tooth Vernier Calipers are made in two sizes. No. 456B is graduated in 40ths (.025") with vernier reading same as any conventional vernier gage while No. 456A is graduated in 50ths (.020"). The procedure for reading these gages is exactly the same as for vernier calipers, height and depth gages described on page 11. Before measurement, however, the gear blank diameter should be carefully determined. Since this may be slightly larger or smaller than the correct diameter, proper allowance must be made when setting the vertical slide. This allowance should be one-half the difference between the correct and actual diameter of the gear.

Figures for determining depth settings on the vertical slide and caliper readings on the horizontal slide are tabulated on the following page.



Chordal Thickness of Gear Teeth Basis of 1 Diametral Pitch

S = Module or addendum, or distance from top to pitch line of tooth

s'' = Corrected S = H + S

t'' = Chordal thickness of tooth

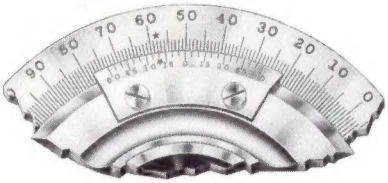
H = Height of arc

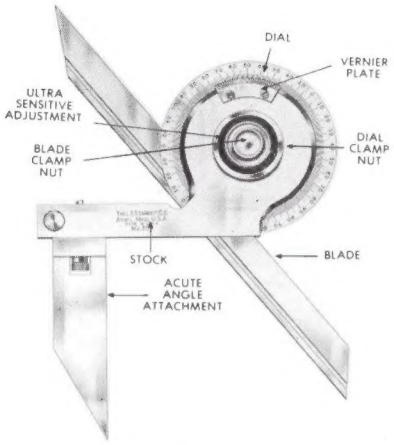
When using gear tooth vernier caliper to measure coarse pitch gear teeth, the chordal thickness t'' must be known, since t'' is less than the regular thickness AB measured on the pitch line. In referring to the table below, note that height of arc H has been added to the addendum S, the corrected figures to use being found in column s''.

For any other pitch, divide figures in table by the required pitch.

No. of Teeth	t''	s''	No. of Teeth	t''	s''	No. of Teeth	t''	s''
6	1.5529	1.1022	**51**	1.5706	1.0121	**96**	1.5707	1.0064
7	1.5568	1.0873	**52**	1.5706	1.0119	**97**	1.5707	1.0064
8	1.5607	1.0769	**53**	1.5706	1.0117	**98**	1.5707	1.0063
9	1.5628	1.0684	**54**	1.5706	1.0114	**99**	1.5707	1.0062
10	1.5643	1.0616	**55**	1.5706	1.0112	**100**	1.5707	1.0061
11	1.5654	1.0559	**56**	1.5706	1.0110	**101**	1.5707	1.0061
12	1.5663	1.0514	**57**	1.5706	1.0108	**102**	1.5707	1.0060
13	1.5670	1.0474	**58**	1.5706	1.0106	**103**	1.5707	1.0060
14	1.5675	1.0440	**59**	1.5706	1.0105	**104**	1.5707	1.0059
15	1.5679	1.0411	**60**	1.5706	1.0102	**105**	1.5707	1.0059
16	1.5683	1.0385	**61**	1.5706	1.0101	**106**	1.5707	1.0058
17	1.5686	1.0362	**62**	1.5706	1.0100	**107**	1.5707	1.0058
18	1.5688	1.0342	**63**	1.5706	1.0098	**108**	1.5707	1.0057
19	1.5690	1.0324	**64**	1.5706	1.0097	**109**	1.5707	1.0057
20	1.5692	1.0308	**65**	1.5706	1.0095	**110**	1.5707	1.0056
21	1.5694	1.0294	**66**	1.5706	1.0094	**111**	1.5707	1.0056
22	1.5695	1.0281	**67**	1.5706	1.0092	**112**	1.5707	1.0055
23	1.5696	1.0268	**68**	1.5706	1.0091	**113**	1.5707	1.0055
24	1.5697	1.0257	**69**	1.5707	1.0090	**114**	1.5707	1.0054
25	1.5698	1.0247	**70**	1.5707	1.0088	**115**	1.5707	1.0054
26	1.5698	1.0237	**71**	1.5707	1.0087	**116**	1.5707	1.0053
27	1.5699	1.0228	**72**	1.5707	1.0086	**117**	1.5707	1.0053
28	1.5700	1.0220	**73**	1.5707	1.0085	**118**	1.5707	1.0053
29	1.5700	1.0213	**74**	1.5707	1.0084	**119**	1.5707	1.0052
30	1.5701	1.0208	**75**	1.5707	1.0083	**120**	1.5707	1.0052
31	1.5701	1.0199	**76**	1.5707	1.0081	**121**	1.5707	1.0051
32	1.5702	1.0193	**77**	1.5707	1.0080	**122**	1.5707	1.0051
33	1.5702	1.0187	**78**	1.5707	1.0079	**123**	1.5707	1.0050
34	1.5702	1.0181	**79**	1.5707	1.0078	**124**	1.5707	1.0050
35	1.5702	1.0176	**80**	1.5707	1.0077	**125**	1.5707	1.0049
36	1.5703	1.0171	**81**	1.5707	1.0076	**126**	1.5707	1.0049
37	1.5703	1.0167	**82**	1.5707	1.0075	**127**	1.5707	1.0049
38	1.5703	1.0162	**83**	1.5707	1.0074	**128**	1.5707	1.0048
39	1.5704	1.0158	**84**	1.5707	1.0074	**129**	1.5707	1.0048
40	1.5704	1.0154	**85**	1.5707	1.0073	**130**	1.5707	1.0047
41	1.5704	1.0150	**86**	1.5707	1.0072	**131**	1.5708	1.0047
42	1.5704	1.0147	**87**	1.5707	1.0071	**132**	1.5708	1.0047
43	1.5705	1.0143	**88**	1.5707	1.0070	**133**	1.5708	1.0047
44	1.5705	1.0140	**89**	1.5707	1.0069	**134**	1.5708	1.0046
45	1.5705	1.0137	**90**	1.5707	1.0068	**135**	1.5708	1.0046
46	1.5705	1.0134	**91**	1.5707	1.0068	**150**	1.5708	1.0045
47	1.5705	1.0131	**92**	1.5707	1.0067	**250**	1.5708	1.0025
48	1.5705	1.0129	**93**	1.5707	1.0067	**Rack**	1.5708	1.0000
49	1.5705	1.0126	**94**	1.5707	1.0066			
50	1.5705	1.0123	**95**	1.5707	1.0065			

How To Read A Universal Bevel Protractor With Vernier





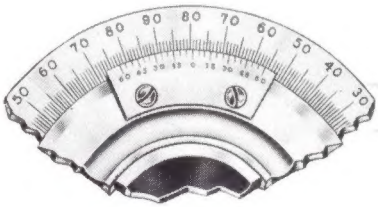
Starrett No. 359 Universal Bevel Protractor with vernier measures any angle to 1/12 of a degree or 5 minutes. The blade and dial may be rotated as a unit to any desired position and locked in place by means of the dial clamp nut. The ultra sensitive adjustment permits very accurate settings. The blade may be extended in either direction and locked against dial by tightening blade clamp nut which operates independently from the dial clamp nut.

The protractor dial is graduated 360° reading 0-90°, 90°-0, 0-90°, 90°-0. Each ten degrees is numbered, and each five degrees is indicated by a line longer than those on either side of it. The vernier plate is graduated in such a way that 12 spaces occupy the same space as 23 spaces on the dial. The difference between the width of one of these 12 vernier plate spaces and two of the 23 dial spaces is therefore 1/12 of a degree or 5 minutes. Thus each space on the vernier plate equals 5 minutes.

To read the protractor, note how many degrees can be read up to the zero line on the vernier plate, then add the number of minutes indicated by the line beyond the zero on the vernier plate which exactly coincides with a line on the dial. Remember—each line on the vernier plate is 5 minutes. EXAMPLE: In the illustration above, the zero line on the vernier plate is positioned slightly beyond 50°. Looking to the left along the vernier plate, you will notice that the "20" graduation coincides exactly with a line on the dial (indicated by stars). Thus 20 minutes must be added to the whole degree reading of 50 making the reading 50 degrees, 20 minutes (50°20').

Test Reading

Write answer to test reading on dotted line below.

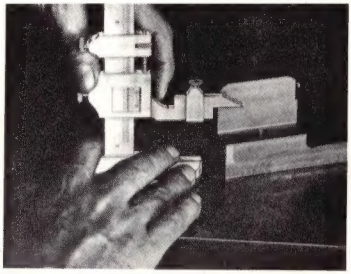


Reading . . . . . .

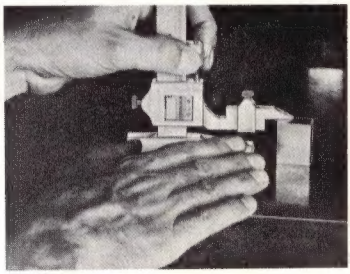
Answer: 67°15'

How to Care for Vernier Gages

Like any precision measuring tool, a vernier gage requires a reasonable amount of care to insure continued accuracy and ease of operation. Much of this care is everyday routine in good shop housekeeping and the rest a matter of periodic inspection and adjustment.



A vernier gage should be handled gently, but firmly **and never forced** in obtaining measurements. Bring the movable contact surface as close to work as possible by hand (right) before using fine adjusting nut. Keep work and gage measuring surfaces free of dirt and grit to prevent inaccuracy and damage to precision lapped surfaces . . . wipe gage carefully after use and store in case with clamp screws loosened. When vernier gage is temporarily set down on the bench, be sure



it lies flat and well away from the edge.

Check vernier gage periodically for accuracy at the zero line. In the case of the vernier caliper and gear tooth vernier calipers, bring the nibs together and check alignment of zero lines on beam and vernier plate. Vernier depth gages are checked by placing base on surface plate and lowering blade until it too contacts the surface plate. Vernier Height 12" and larger gages are checked against a standard (left).

Because of precision fitting of slides

an occasional drop of Starrett Precision Instrument Oil should be used for free-running performance. Never use emery cloth to polish gage contact surfaces, or attempt to adjust gage for wear. Complete repair facilities are maintained at the Starrett factory for this purpose with prompt service assured.

THE L. S. STARRETT COMPANY, ATHOL, MASSACHUSETTS, U.S.A.

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